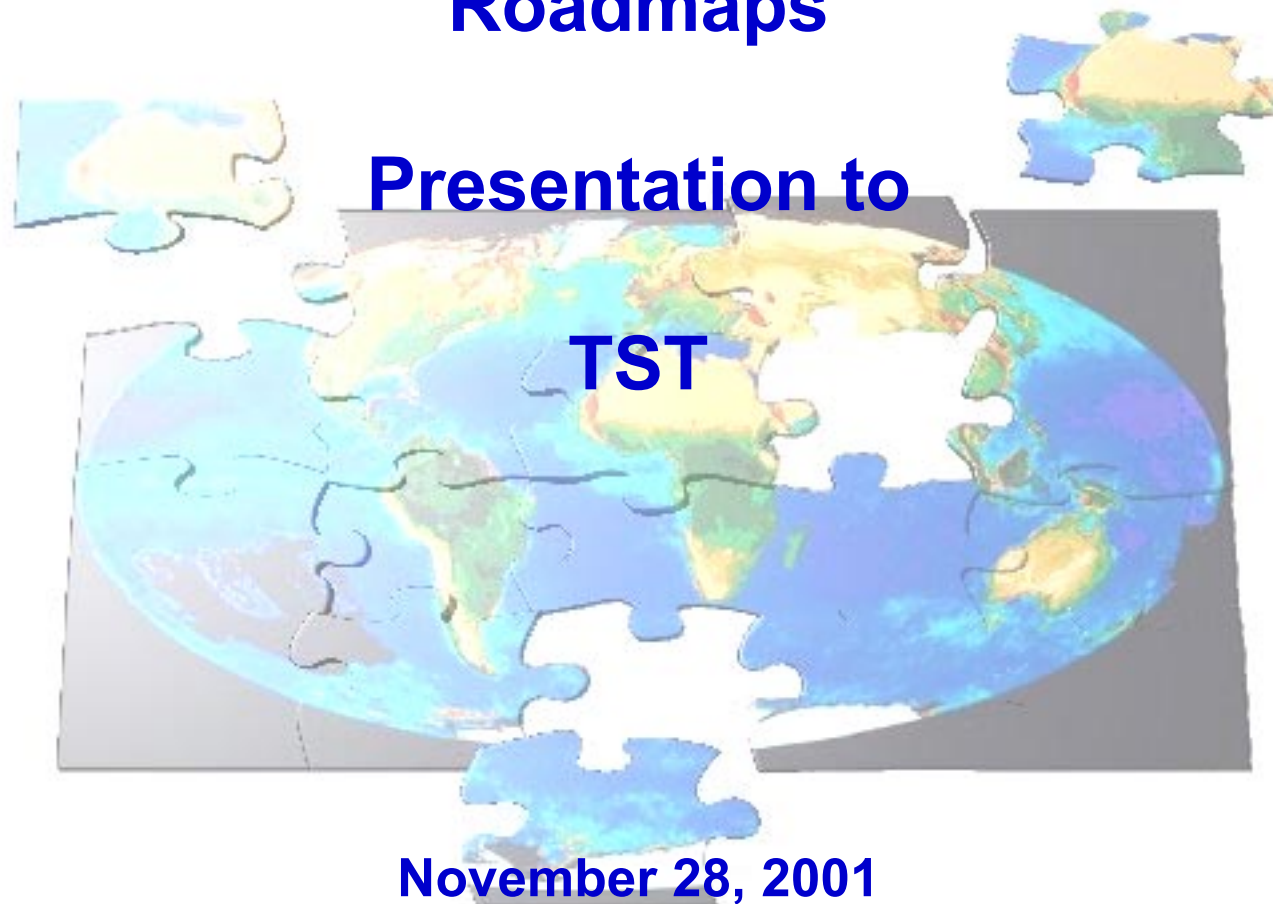


**Some thoughts on
Technology Planning, Development and
Roadmaps**

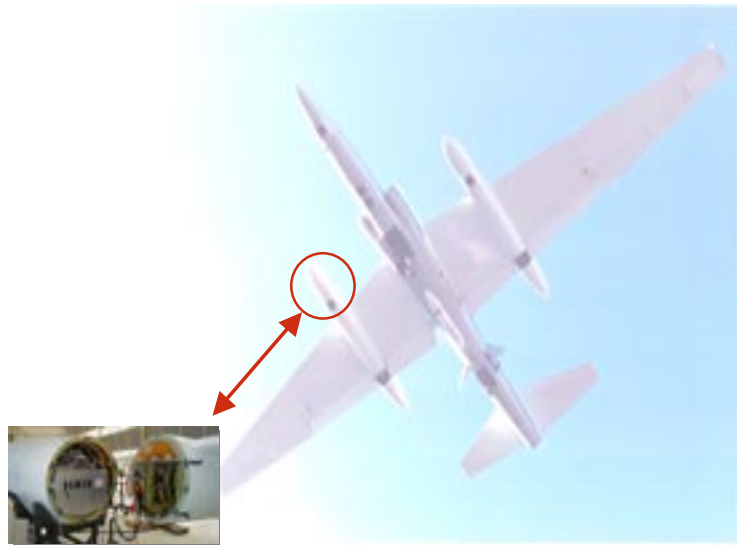


**November 28, 2001
Loren Lemmerman - ESTO**

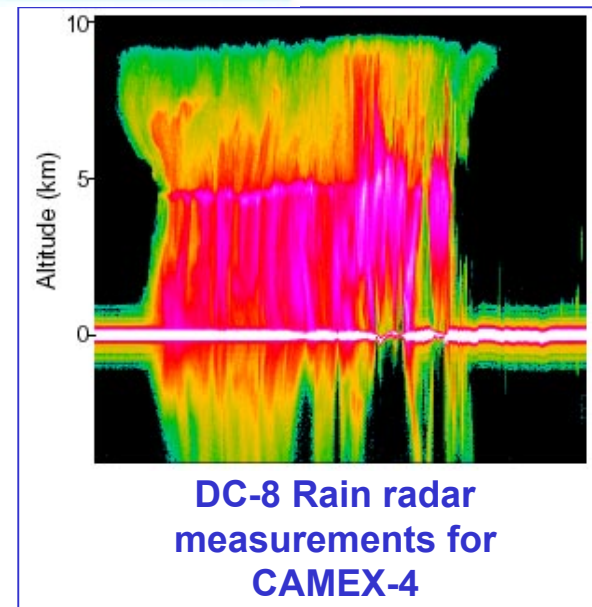
ESTO has been Extraordinarily Successful in Earth Science Technology....

- All awards directly applicable to future Earth Science missions
- All awards highly effective in developing technology products
- Significant deliveries made within first 3 years of program

Examples of Round 1 successes



**HAMSR
(High Altitude
MMIC Sounding
Radiometer)
measuring
temperature, water
vapor and clouds
for CAMEX-4**



But, We Could Do Better



Goal:

Eliminate “Speckled Puppy” Problem

- Understand All the Needs
- Focus on Obtaining Resources

Goal:

Minimize Programmatic New Technology Risk

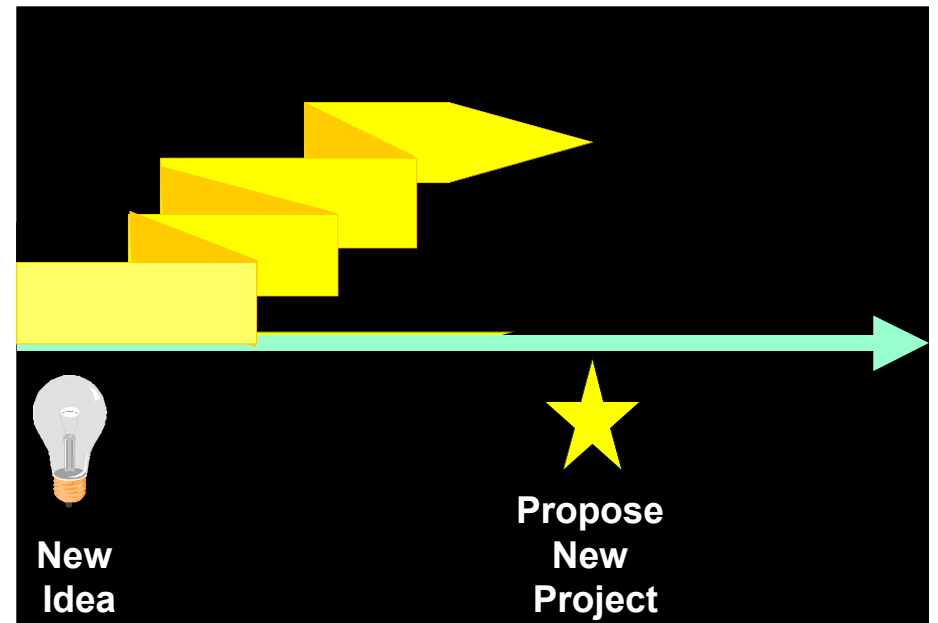
- Understand the Technology Development Sequence
- Assess Technology Readiness at Time of Proposal

Conclusion:

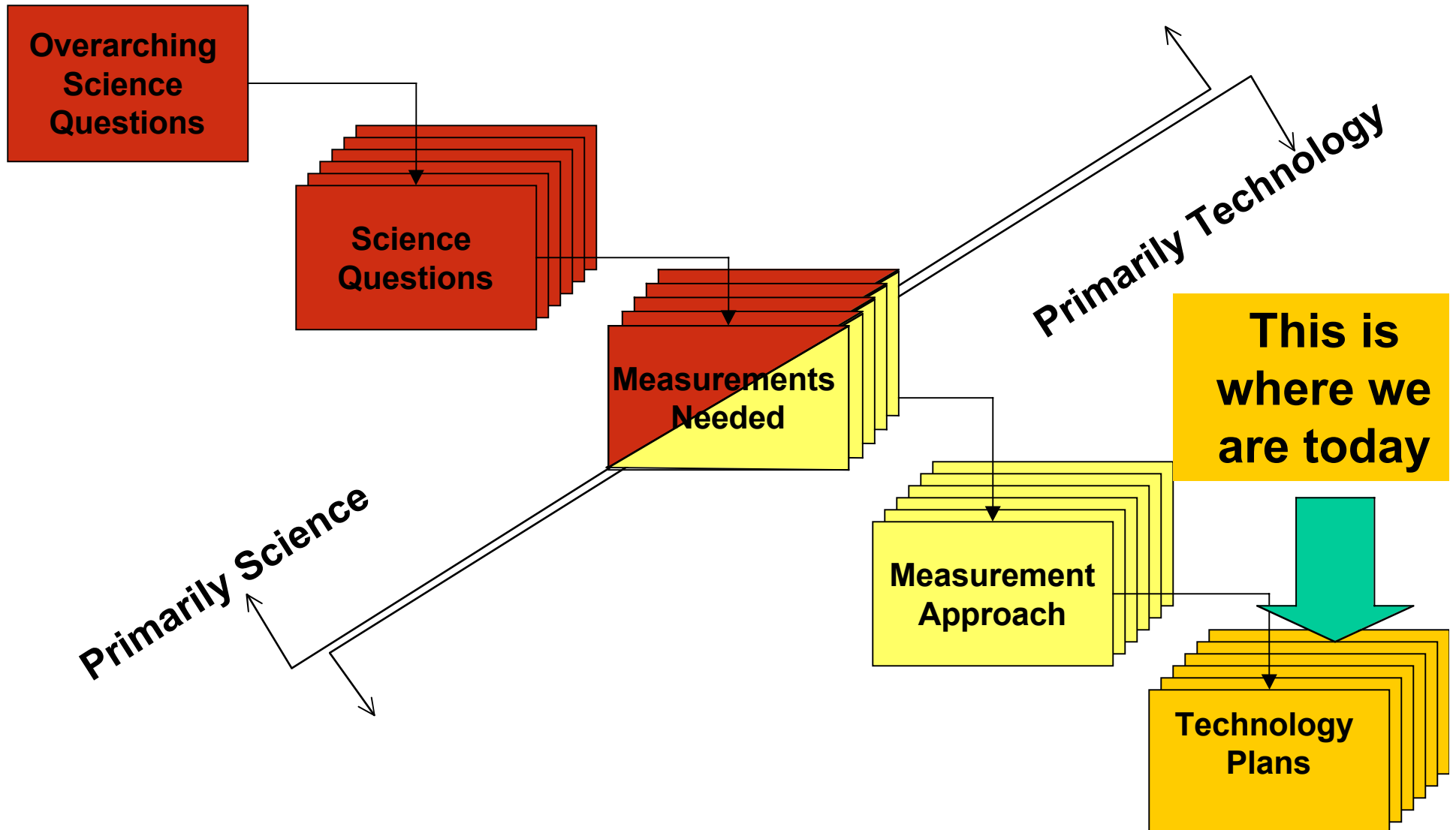
Do more

IN-DEPTH

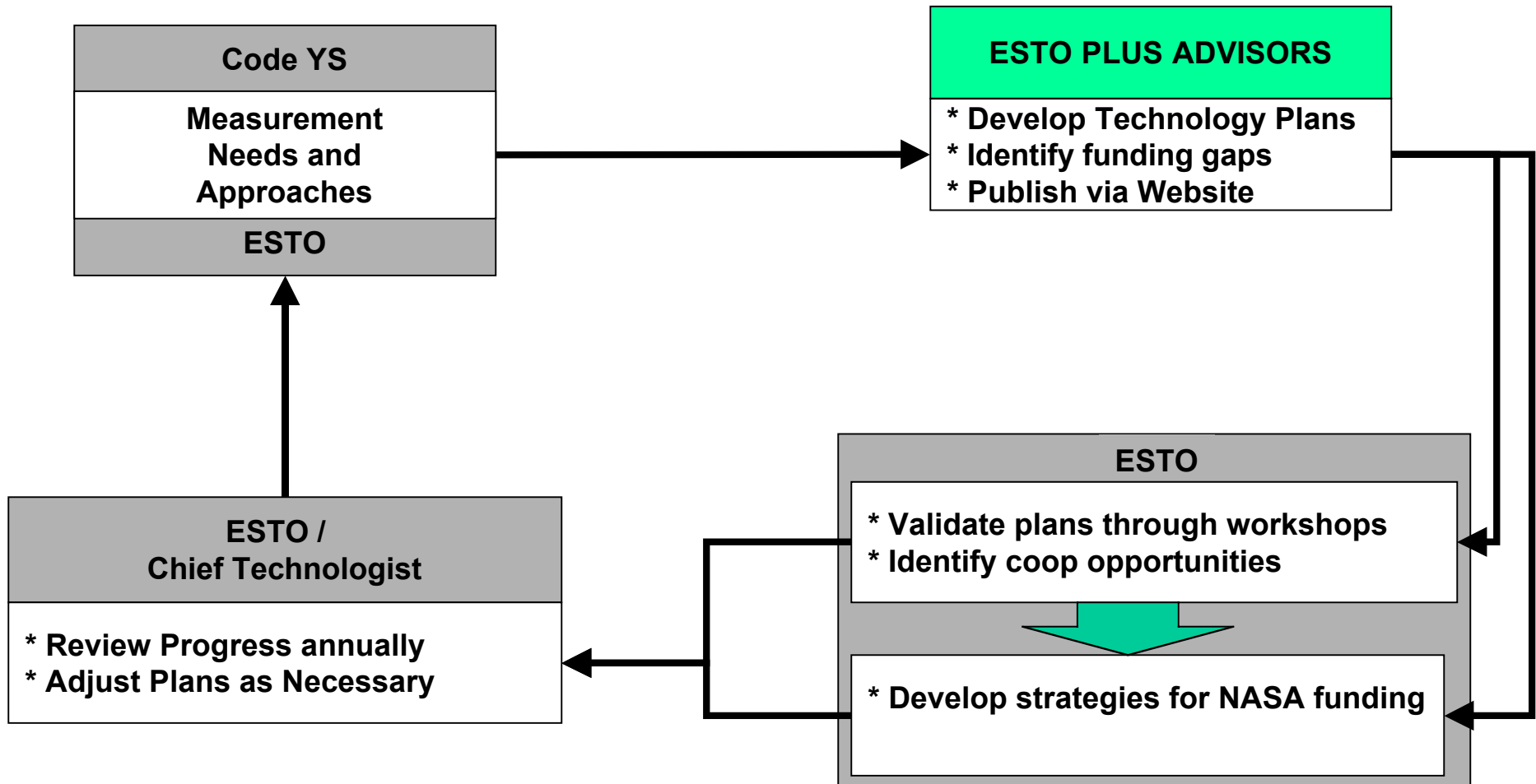
Planning



Technology Needs Defined by Requirements Flowdown



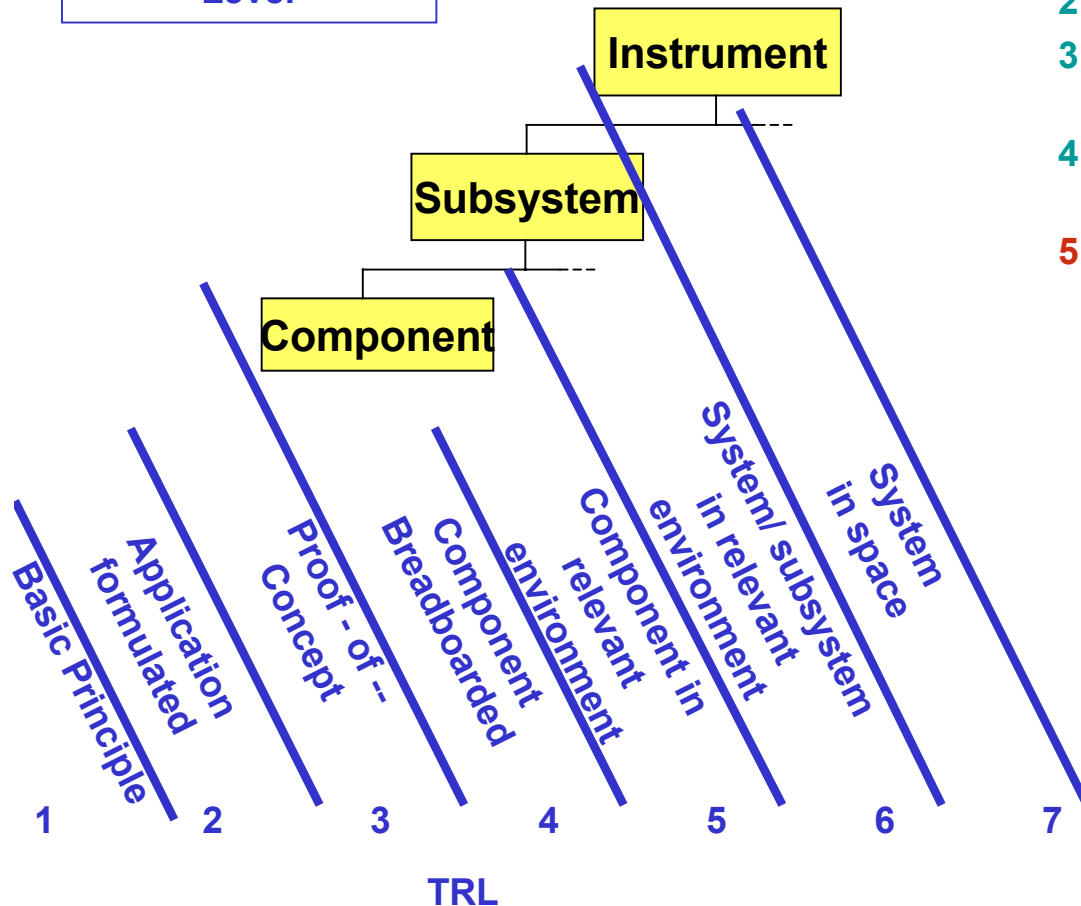
What is the Whole Process?



Technology Readiness Assessment Critical to Technology Planning

Tutorial: How TRL maps to Technology Products

TRL = Technology
Readiness
Level



Technology Planning or Roadmapping Steps

1. Decompose future technology product into lowest level components
2. Assess current TRL of each component
3. Assess cost and time needed to bring each component up the TRL scale
4. Develop sequence of addressing technology tasks
5. Predict availability based on funds available

Planning Products

Readiness Dates

Resource Plans

Pictorial representations

Funding Priorities

lemmerman:

The concept here is the following:

1. Understand the problem (be able to develop database of needs)
2. Lay out a tentative phasing of tasks that is logical
3. Assess delivery dates that reflect funds available

Technology Planning

WBS of
technology
product

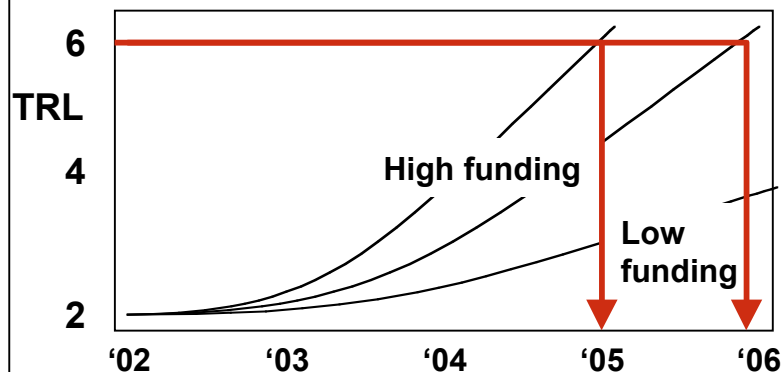
Distribute
Tasks
Logically

Affects
Delivery

Phasing of tasks

	2	3	4	5	6	7
Diffraction-limited 0.5-m aperture optics						
Hybrid diffractive/holographic elements						
Compact balanced photomixer						
Autonomous alignment maintenance						
Advanced Optical Subsystem						
Broadly tunable, high spectral purity semiconductor oscillators						
Multi-GHz tunability and tuning agility						
Reference Oscillator Assembly						
High-power laser diode arrays for transmitter pumping						
Laser transmitter testbed evaluation						
Diode Pump Laser Technology						
Advanced Laser						
Advanced Lidar system						

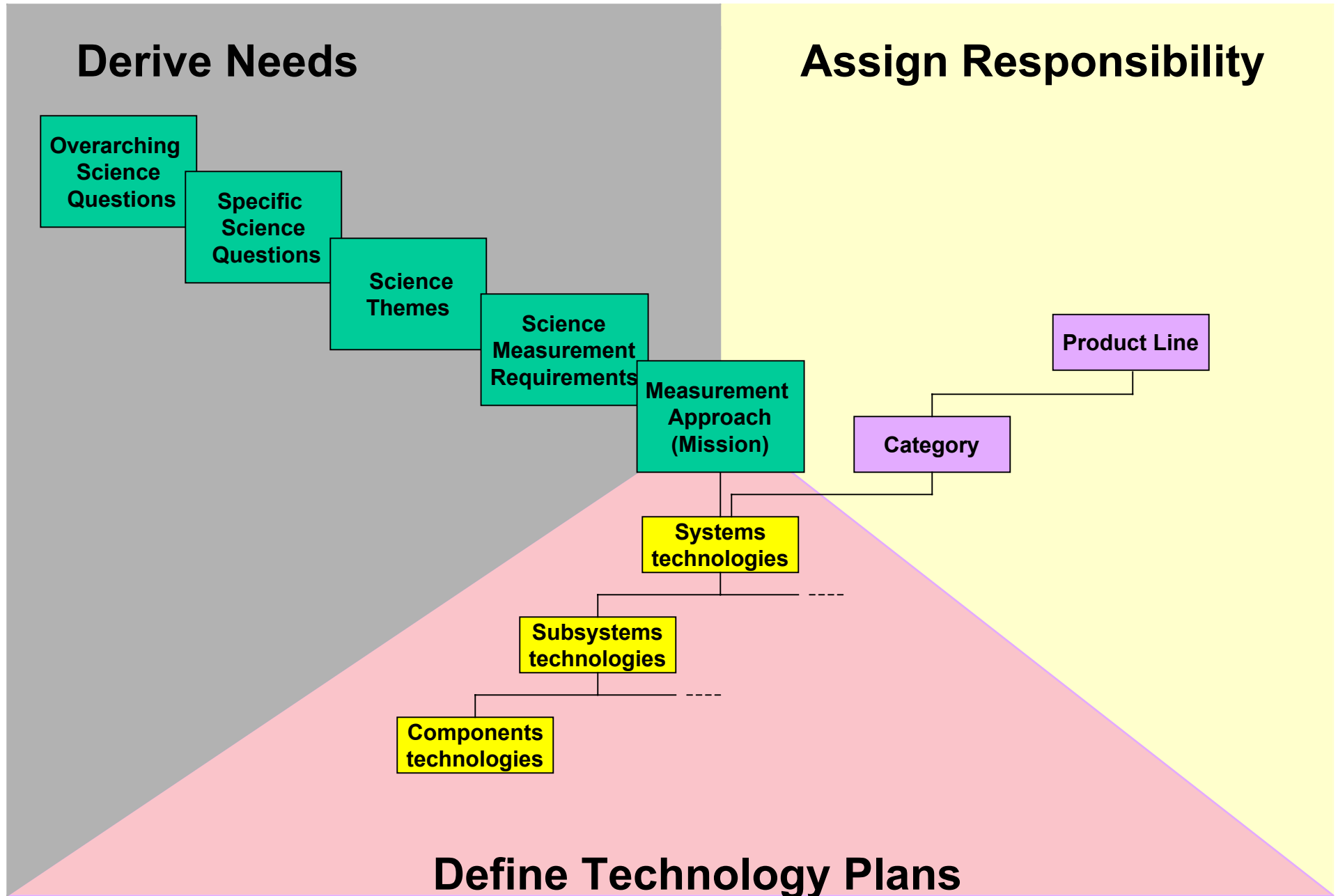
Predicted availability



Database of tasks and costs

- **Developing database**
 1. Define desired technology products (tangibles!)
 2. Develop product breakdown structure for these products
 3. At lowest level (component) perform trl assessment (current status)
 4. Estimate cost and schedule required to advance up trl scale
 5. Develop task phasing leading to desired technology product
- **Estimating delivery dates**
 1. Roll up costs to subsystem / system level using phasing above
 2. For proscribed levels of funding, determine when trl levels can be reached

Top- to - bottom Database



Database Development

Defining products

- Begin with WBS already in existence,namely
 - Product line
 - Category
 - Functional product
 - » Task
- Verify Functional Products [systems] in current database
 - Add / delete to improve
 - Modify definitions if appropriate
- Insert subsystem / component levels
 - Functional products [systems] *have*
 - Subsystems *have*
 - Components *have*
 - » Technology *tasks*

Example of existing database

Missic Mission Name	Lead Cer	Product line	Category	Functional product	Task
ES-6 Ocean Surface Topography	JPL	Adv Instruments	Passive radiometers, FTS	3 Band MMIC Radiometer	Repackage IIP breadboard for space
ES-6 Ocean Surface Topography	JPL	Adv Instruments	Passive radiometers, FTS	3 Band MMIC Radiometer	Test for performance
ES-6 Ocean Surface Topography	JPL	Adv Instruments	Passive radiometers, FTS	IF antenna validation	Develop mechanism breadboard
ES-6 Ocean Surface Topography	JPL	Adv Instruments	Passive radiometers, FTS	IF antenna validation	Develop antenna breadboard
ES-6 Ocean Surface Topography	JPL	Adv Instruments	Passive radiometers, FTS	IF antenna validation	Range test of breadboard
ES-6 Ocean Surface Topography	JPL	Adv Instruments	Passive radiometers, FTS	Validate 5 frequency antenna system	breadboard antenna
ES-6 Ocean Surface Topography	JPL	Adv Instruments	Passive radiometers, FTS	Validate 5 frequency antenna system	Integrate with 5 frequency feedhorn
ES-6 Ocean Surface Topography	JPL	Adv Instruments	Passive radiometers, FTS	Validate 5 frequency antenna system	Range test of system
ES-7 Stratospheric Composition Measurement	GSFC	Adv Instruments	Passive radiometers, FTS	Array Microwave Limb Sounder	MMIC Receivers
ES-7 Stratospheric Composition Measurement	GSFC	Adv Instruments	Passive radiometers, FTS	Array Microwave Limb Sounder	MMICs
ES-7 Stratospheric Composition Measurement	GSFC	Adv Instruments	Passive radiometers, FTS	Antenna Systems	Thermal HIS
ES-7 Stratospheric Composition Measurement	GSFC	Adv Instruments	Passive radiometers, FTS	Antenna Systems	Calibration
ES-9 Global Precipitation	GSFC	Adv Instruments	Passive radiometers, FTS	Compact Synthetic Aperture Radiometer	ASIC-based digital correlator
ES-9 Global Precipitation	GSFC	Adv Instruments	Passive radiometers, FTS	Compact Synthetic Aperture Radiometer	Graphite-exopy composite waveguide antenna
ES-9 Global Precipitation	GSFC	Adv Instruments	Passive radiometers, FTS	Compact Synthetic Aperture Radiometer	Lightweight, low power MMIC receiver
ES-9 Global Precipitation	GSFC	Adv Instruments	Passive radiometers, FTS	Compact Synthetic Aperture Radiometer	Spaceborne Precipitation Radar
EX-3 Cloud-Radiation Feedback Research	LaRC	Adv Instruments	Passive radiometers, FTS	Sub-mm Radiometer	Receiver Demonstration
EX-3 Cloud-Radiation Feedback Research	LaRC	Adv Instruments	Passive radiometers, FTS	Sub-mm Radiometer	THz Array Down Converter
EX-3 Cloud-Radiation Feedback Research	LaRC	Adv Instruments	Passive radiometers, FTS	Sub-mm Radiometer	THz Oscillator
EX-4A Soil Moisture and Ocean Salinity Observing	GSFC/JPL	Adv Instruments	Passive radiometers, FTS	Antenna Technology	Trade Studies
EX-4A Soil Moisture and Ocean Salinity Observing	GSFC/JPL	Adv Instruments	Passive radiometers, FTS	Synthetic aperture radiometry	2D STAR Instrument
EX-4A Soil Moisture and Ocean Salinity Observing	GSFC/JPL	Adv Instruments	Passive radiometers, FTS	Synthetic aperture radiometry	Data transfer/interconnects

Defining Products

Developing WBS for these products

- **Requires that we be able to decompose product logically**
- **Allows us to perform TRL assessment at consistent levels**
 - **Provides approach for aggregating lower level TRL information**
 - **Provides a basis of phasing developments consistent with TRL advancement**
 - **Separate topic of TAWG**

lemmerman:

Quantum Devices

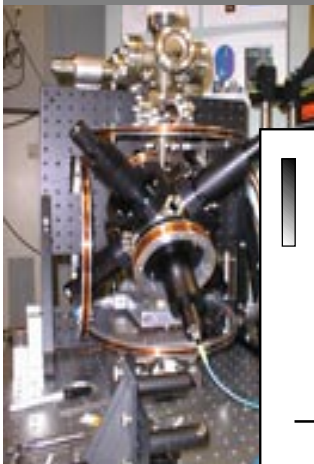
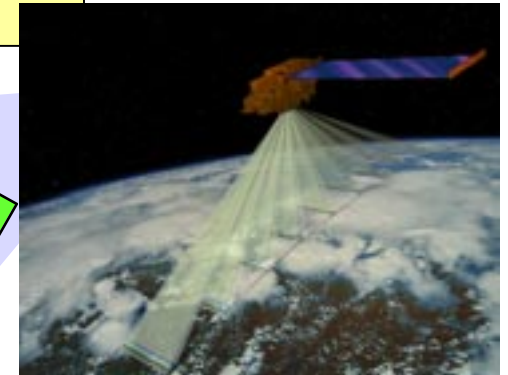
If we follow the approach recommended up to this point, we will be able to display roadmaps in any one of a number of formats (slides 13-15 are such examples) but with the **UNIQUE** feature of have some consistency and underlying basis of representation.

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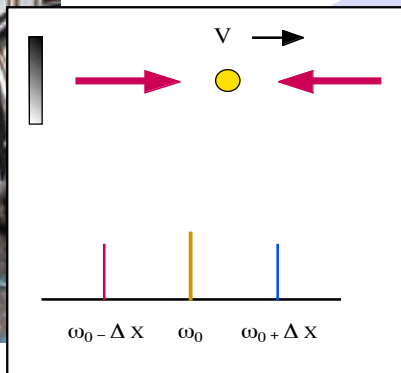
Future Mission Applicability

- GRACE Follow-on
- Hydrology
- Tectonic and glacial motions
- Volcano dynamics
- Geodesy
- Ice mass flux

Aircraft Demo (Gravity Gradiometer)



Atom
manipulation



Doppler Cooling of
Atoms

TECHNOLOGY PAYOFF:

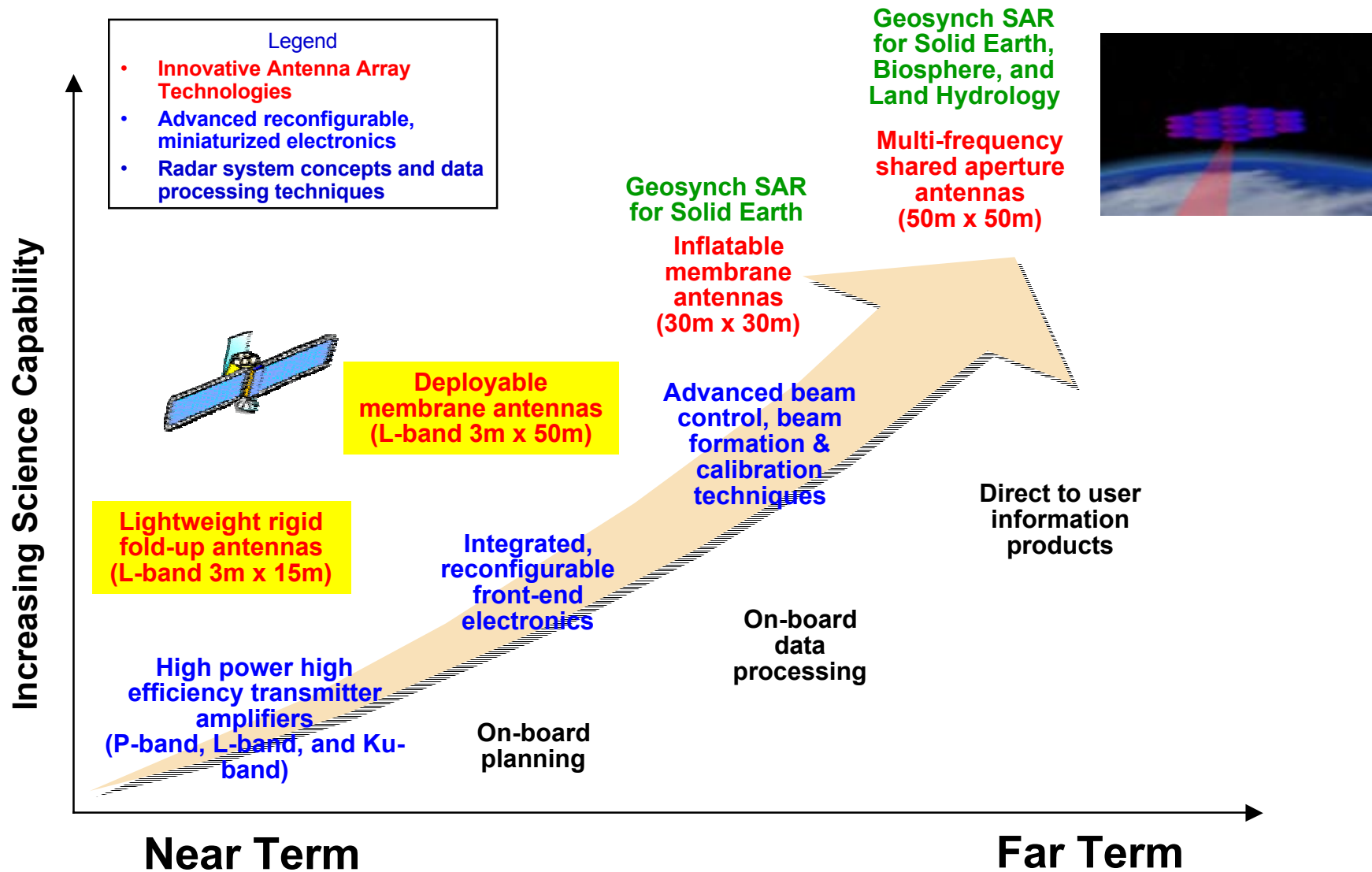
- Stabilized laser systems
- Precision Metrology
- Precision Gravity Gradiometry

2000

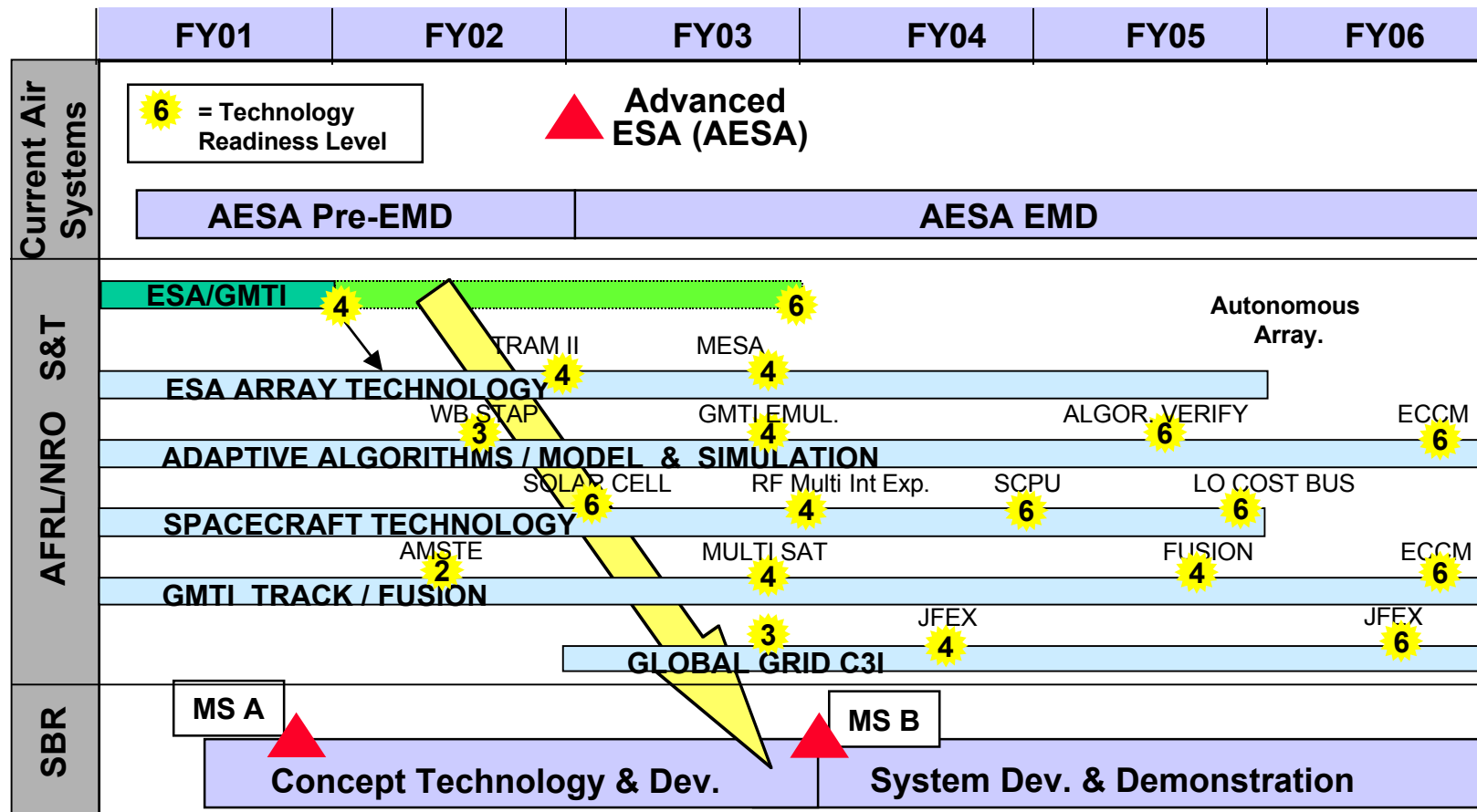
2010

SAR

(Solid Earth, Biosphere, Land Hydrology)



SBR Technology Roadmap



**AFRL S&T Program on Space GMTI Needed for Milestone B;
Leverages JSTARS Developments for RTIP/AMSTE**